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STREAM DISCHARGE MEASUREMENT USING A MODIFIED TECHNIQUE

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ABSTRACT

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STREAM DISCHARGE MEASUREMENT
USING A MODIFIED TECHNIQUE

ABSTRACT

Stream discharge measurement with a Price AA current meter and wading rod, using U.S. Geological Survey techniques, is a time consuming process. This paper describes a measurement methodology for small streams, with less than ideal measuring conditions, that reduces process time by 35-50 percent. Accuracy of current-meter flow measurements, as compared to Parshall flume measurements, range from eight percent at a flow rate of 1 ft^3/sec to about three percent at 10 ft^3/sec. At flows approaching 100 ft^3/sec, differences will be about 1%. Reproducibility of current-meter flow measurements is within three percent.

INTRODUCTION

The procedure for measuring stream discharge (USDI, Geological Survey, 1976) with a Price AA current-meter was modified to permit discharge measurements at locations not usually appropriate for these measurements. Stream characteristics normally required for discharge measurements such as straight stream reaches with threads of velocity parallel to each other, and flat streambeds which eliminate vertical components of velocity (USDI, Geological Survey, 1976), are not as essential with this methodology. The modified procedure reduces the time required for discharge measurement, eliminates the need to set up stream velocity cells with five percent to ten percent of flow in each cell, and operate within velocity and depth specifications for the AA current-meter (USDI, Geological Survey, 1976). The modified method is accurate and reproduceable.

The purpose of this paper is to describe the modified discharge measuring technique, and to compare stream discharge measured by the modified technique to discharge measured in Parshall flumes.

METHODOLOGY

Two Parshall flumes of 2.5 ft. and 6.0 ft. throat widths were installed at unimproved sites to evaluate the modified technique. The test sites are located on Chamberlain Creek and McElwain Creek in Powell County, Montana. Chamberlain Creek has a rocky bottom and banks and receives flow from a 'bottomless-arch' culvert. Flow in excess of 10 ft^3/sec is turbulent. The McElwain Creek site has a streambed composed of fine gravels and soil materials, and receives flow from a stream meander which is partially obstructed by shrub-type vegetation.

The technique, which may be used on streams of 2 ft. to 15 ft. in width and up to 2.5 ft. in depth, is as follows:

1. Install the measuring tape at right angles to the direction of flow (tape marked in 1.0 ft. graduations with 0.1 ft. increments).

2. Measure velocity every 0.5 ft. across the channel starting at the point of beginning with a whole number (e.g., 1.0 ft. etc.); at the terminus end of the tape, the last "cell" will usually differ from the 0.5 ft. width. Record the last cell width and accommodate in the calculations.

3. Use the 0.6-depth method (USDI, Geological Survey, 1976). However, at channel edges the 0.6-depth method may be foregone. In this case, measure velocity in cells only if the impeller is fully submerged.

4. Use proper rod-holding and foot positioning techniques (USDI, Geological Survey, 1976).

5. When velocities are low and the impeller is turning slowly, start the stopwatch at click "0" and count "1" after the second click is heard.

6. Use conventional methods for calculating discharge (USDI, Geological Survey, 1976).

This technique differs from the normal procedure in that:

1. Stream channel constraints are minimal, (i.e., all of the flow is in one channel, channel conditions are as good as can be realized consistent with the measurement location being in the right place for the project, accessibility, etc.).

2. The Price AA meter impeller may not always be at least 0.5 ft. from water surface and streambed.

3. Velocities below the minimum specified for the Price AA meter are of no concern as long as the impeller turns continuously.

4. The 0.5 ft. cell width becomes a standard dimension except as noted.

5. It is not necessary to spend time spacing the cells so that each cell has no more than five to ten percent of the total discharge in it.

RESULTS

Correlation of AA meter flow and flow measured in the 2.5 ft. and 6.0 ft. flumes is good as shown by correlation coefficients (r) of 0.998 (refer to Tables 1 and 2).

As accuracy of flume flow is reported to be within two percent with proper installation (Thompson Pipe and Steel Co.; USDI, Bureau of Reclamation, 1975), the high correlation cited above indicates that AA meter flow measurements are similarly accurate.

TABLE 1

2.5 FT. PARSHALL FLUME FLOW VS. AA CURRENT METER FLOW

FLUME FLOW FT^3/SEC	AA METER FLOW FT^3/SEC
10.31(1)	11.87(1)
8.49	8.64
3.72	3.95
3.19	3.46
3.39	3.31
2.21	2.13
1.38	1.29
0.94	0.74

$y = 0.96x + 0.12$

$r^2 = 0.997$

$r = 0.998$

(1) A portion of the stream flow was bypassing the flume at this discharge level. These data were excluded from the statistical analysis.

TABLE 2

6.0 FT. PARSHALL FLUME FLOW VS. AA CURRENT METER FLOW

FLUME FLOW FT^3/SEC	AA METER FLOW FT^3/SEC
17.83	17.67
16.81	16.38
9.79	9.50
10.35	9.42
8.98	9.03
8.20	7.76
6.25	6.14
6.02	6.14
5.13	4.96
3.43	3.22
2.97	2.74

$y = 1.01x + 0.15$

$r^2 = 0.997$

$r = 0.998$

Using the $y = ax + b$ relationship and substituting known values of x in the formula provides the following discharge differences (2.5 ft. flume):

x value of flow, ft^3/sec	differences in flow - calculated vs. flume, %
1.0	8.0
2.0	2.0
5.0	1.6
10.0	2.9
20.0	3.5

Similarly, discharge differences for the 6.0 ft. flume are:

x value of flow, ft^3/sec	differences in flow - calculated vs. flume, %
1.0	16.0
2.0	8.5
3.0	6.0
4.0	4.8
10.0	2.5
100.0	1.2

The flow rates selected for the two flumes span their normal capacity range. In the case of the 2.5 ft. flume, flow differences above the 1.0 ft^3/sec rate will generally be less than eight percent as measured by the AA meter. Accuracy with the AA meter is quite good at higher flows as shown by the data for 6.0 ft. flume. These data show that the modified stream measurement technique is capable of accurate results with discharges in the range of 1.0 to 100 ft^3/sec, based on regression analyses. Accuracy is poorer at low flows (i.e. less than 1.0 ft^3/sec).

The 2.5 ft. and 6.0 ft. flumes are rated for minimum flows of 0.81 and 2.63 ft^3/sec respectively. Therefore, it was not appropriate to evaluate the accuracy of the modified method below 0.81 and 2.63 ft^3/sec.

Replication of AA current meter flow measurements demonstrates that repeat flows will have a difference of less than three percent (Table 3).

TABLE 3

REPLICATION(1) OF AA CURRENT METER DISCHARGE MEASUREMENTS AT TWO FLOW LEVELS

FLOW FT^3/SEC	DIFFERENCE
3.25 ft^3/sec 3.18 ft^3/sec	$\frac{0.07}{3.18} = 0.022 = 2.20\%$
52.81 ft^3/sec 51.39 ft^3/sec	$\frac{1.42}{51.39} = 0.0276 = 2.80\%$

(1) Repeat velocity and depth measurements were made immediately upon completion of the first velocity and depth measurements.

CONCLUSIONS

The modified stream discharge measurement technique, as applied to small streams, can accurately and reliably measure stream discharge. Flow rates greater than 1.0 ft^3/sec will be within eight percent of actual flow as measured by a Parshall flume. At flow rates above 10 ft^3/sec, the differences will be about three percent of flume flow. At flows of about 100 ft^3/sec differences will be approximately one percent of flume flow.

The reduction in time required to run at-a-station discharge compared to usual measurement methods, is estimated to be 35 to 50 percent. Complexity is also reduced. The modified technique is much less laborious and is easier to use than the standard method.

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